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REPAIR AND REHABILITATION OF INDUSTRIAL STRUCTURE-A CASE STUDY

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Abstract: The harsh environment has a significant impact on structures in coastal areas. As a result, building and maintaining structures to ensure that they last as long as they are supposed to might be difficult at times. Due to sea level rise, there will be significant variations in temperature, humidity, water density, wave and current factors, all of which will have an impact on the structures. It hastens the degeneration of the structure, mostly through corrosion, sulphate assault, freezing and thawing, and other factors. The industrial structure in the harbour is taken into account for this study. Because to the hostile marine environment, the breathing structure was seriously injured the roof and truss of the structure are highly corroded and may fall any time and the RC members are losing their strength. To assess the damage to the structure and the state of the existing structure, visual inspection and non-destructive tests such as UPV, rebound hammer, pH, carbonation, corrosion test, delamination, and cover metre tests were undertaken.

Index Terms **– impact, degeneration, non-destructive, delamination.**

I. INTRODUCTION

Civil engineering has seen a lot of growth over the years, and different sorts of structures are being developed using various methods and techniques. Different structures are used for various purpose, for example Buildings, Bridges, Overhead tanks, Highrise structures, Airport, Stadiums etc. Each of the structures is constructed from a different type of materials like concrete, steel, aluminium, composites and also some light-weight materials. Nowadays it may be in-situ or pre-casted as per requirement and economic consideration. The cost of corrosion associated with the pre-mature downturn of concrete structures is about one to two per cent of GDP and which is globally and this is the number and we're probably when we talk about India there is a lot of these estimates are not really available. so we still based on the available data we can say it is more or less than one to two percent or maybe even more and today the situation is much more important because we are constructing a lot of structures and if we do not take care of the quality of construction or in the durability of the structures then in the near future we will have do a huge amount of repair work which will be sometimes in very difficult to even manage we may not have enough man power to handle such problems.

Each and every structure constructed is subjected to geophysical and man-made loads during their service life, these applied loads are analysed during the design process in-order to get safety, stability and serviceability. When the quality of these loads exceeds the capacity due to some defect in construction or material quality, it degrades the structure and causes several damages. When these structures are distressed or deteriorated before its service life or design life then it is necessary to monitor the structure to overcome this kind of instability. The decision to repair the structure is necessary, considering the loss of income and the environmental factor, due to the disruption of the economy and the functioning of the structure to build another new structure in the damaged structure space. There are variety of structural upgradation and retrofitting techniques which have been involved over the year interpret of different structures and has also have been used.

II. METHODOLOGY

For determining the structural health of weir-house located in Mangalore port, as a case study first the complete physical inspection for that structure is done to find current situation of that structure so that further action can be decided. The data which is collected from the physical inspection is helped to determine the causes of deterioration. After the collection of primary data by physical inspection, collected secondary data from the respected office. Because the unavailability of all the data we carried out further detailed study using the available data. To find the exact present condition of structure we performed NDT and obtained the result, which gave the exact condition of the structure. Base on the obtained result we choose the further action to be performed. Obtained result is analyzed and concluded.

III. ISPECTION AND TESTING

- Physical inspection.

(General Details)

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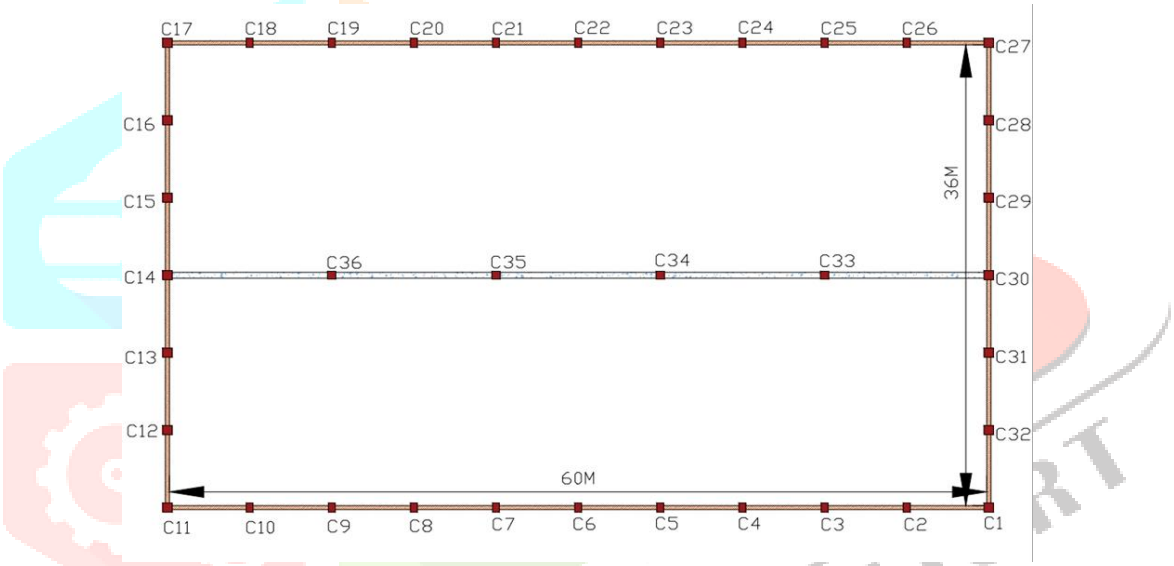
1	Name and address of building/ year of construction	Transit shed no1 / 1972-73
2	Type of building	Partially RCC
3	No of storey of building	single
4	Description of usage of building	warehouse
5	Type of roofing	AC sheets with steel truss
6	Maintenance history of building if known	------



Existing column layout

Overview from Physical Inspection

As a first part of study the physical inspection is carried out and the damages found on the structure are recorded.

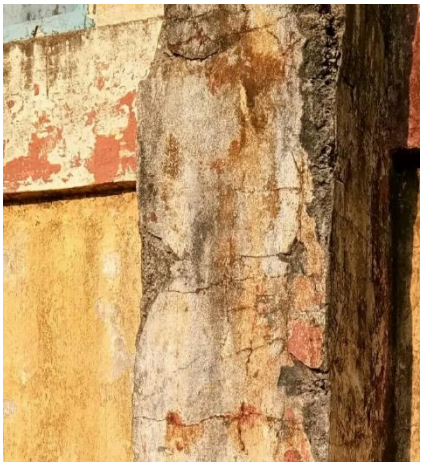
Hairline cracks: The hairline cracks are observed in highest number on the structure. Mainly we can observe hairline cracks on the horizontal members and these hairline cracks are formed mainly due to temperature stress. The hairline cracks are also called as lighter cracks which are not so hazardous and can repaired easily.

Wider cracks: The wider cracks are observed mainly on the vertical members(columns) which are caused by stress developed inside the column due to corrosion. These cracks are also even responsible for higher structural damage.

Spalling: Spalling of concrete cover as well as plaster can be seen extremely mainly in columns as well as masonry walls and also lightly in beams. The spalling of concrete covers happened due to debonding of concrete from the reinforcement bar.

Cavity: The cavity is observed in vertical member(column) mainly at the bottom. Acid and chemical attacks are responsible for internal cavity as well as honeycombing of concrete.

Corrosion: The corrosion of reinforcement is in high range on the exposed face of the structure which is directly responsible for formation of internal stresses inside the reinforced concrete members. The roof truss is also corroded completely and may fall any time.



Hairline Cracks on column

Wider cracks on Column

Corrosion of Rebar

Environmental Effect

The structure is located near harbour which is extremely exposed to chloride, carbon and many acid attacks. when the structure is alternately exposed to drying and wetting cycle, resulted in crystallisation of salts in the porous caused the stress that resulted in the formation of crack. even after the formation of cracks, the continuous storage of fertilizer and chemicals caused the chemical effect that resulted in acceleration of corrosion. This was the main reason for deterioration.

IV. DETAILED INVESTIGATION

The knowledge provided by the preliminary design is required once the investigation isn't conclusive and when additional investigation is needed for repair / retrofitting work. An in-depth study is not required to document the status of the entire structure; nonetheless, the preliminary investigation's recommendations were backed exclusively by the elements behind the investigation.

Range of Delamination and reduction of column size

VERY SEVERE	SEVERE	MEDIUM	LIGHTER
C2 (bottom and edge spall) C4 (plaster and edge spall) C6(cover spall) C8(plaster with cracks) C15(spall with cracks) C18(edge spall) C21(bottom spall) C22 C33, C35, C34, C36 highly damaged columns	C3, C5, C13, C16, C19, C20, C23, C26, C29, C32 having wider cracks and spalled intermediately	C7, C9, C10, C12, C15, C17, C25, C30, C31 Having spalled plasters and lighter edge spall	C1 C11 C14 C17 C27 C24 Plaster spall and lighter cracks

Measurement of Crack Width and Depth

The crack width and depth of each structural element is measured. The width of wider cracks is measured by measuring scale and the depth of crack is measured with the help of sharp thin tool. The maximum and minimum crack width is found to be 12.7mm and <1mm, and maximum and minimum crack depth is 28mm and <1mm.

Roof Truss

The proposed trusses are highly damaged due to corrosion and the bracing joints are broken as the proposed truss becomes more wrinkled and, due to high stress the truss started bending as well as braking along with truss the roof sheets are also damaged and started spalling.

Existing Roof Truss

V. TESTING OF STRUCTURE

As per Indian standard's the existing shed is imposed to non-destructive tests (NDT) so that the structure is tested ideally without any damages.

1. Rebound Hammer test.
2. Delamination /Sounding method.
3. Carbonation Test.
4. pH Test.
5. Ultrasonic Pulse Velocity Test (UPVT).
6. Cover Meter Test.
7. Corrosion Test.

VI. RESULT AND DISCUSSION

6.1 Rebound Hammer test.

The rebound hammer also called Schmidt hammer – a swiss hammer is one of the oldest & best-known methods for comparing the concrete in different parts of structure.

Column No	Position	Avg Rebound No	Compressive strength (Mpa)
C6, C13 (min)	0 degree (HZL)	25	16
C12 (max)	0 degree (HZL)	49	60

As per the research, the compressive strength of structural member is more than 40mpa there is a probability of carbon attack so it is recommended to go for carbonation test.
The minimum value of compressive strength which is obtained from test (i.e. 16) is categorised as poor.
The lesser values of compressive strength reveal us poor strength and poor quality of concrete.

6.2 Carbonation Test.

As per obtained result the depth of carbonation is more than reinforcement level i.e. >60mm.

The carbonation test gives the depth of carbon attack on the structural member. From the obtained result it is noticed that the depth of carbon is up-to reinforcement level, so the structure is considered as completely carbonated.

6.3 Delamination /Sounding method.

The Delamination/Sounding survey clearly reveals the quality of surface in different position. It is more of often hollow sounds at the bottom rather than top portions.

6.4 pH Test.

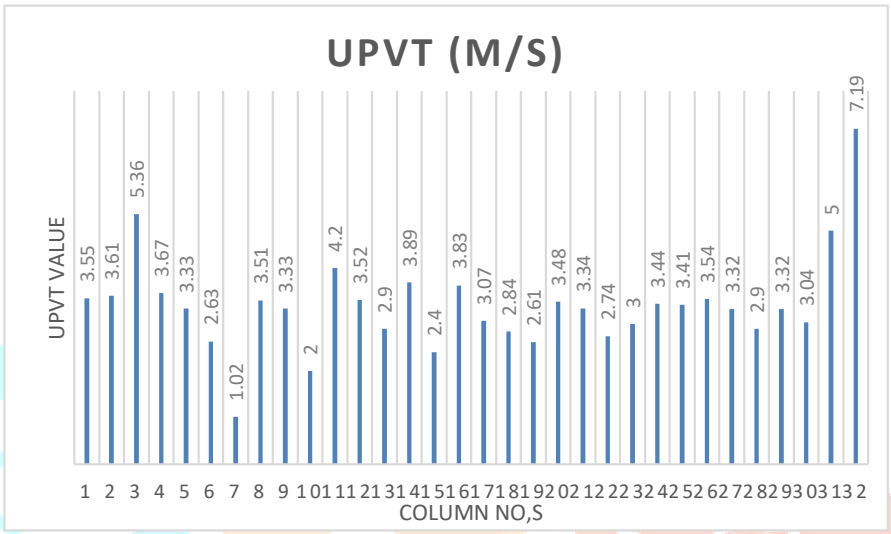
The range of pH is usually 12.5 to 13.8 for fresh and Hardened concrete.

Specimen type: Concrete cover(A).

Specimen	Range of pH
A	9

The obtained range of pH is significantly harmful to existing structure mainly erosion of structure due to corrosion.

6.5. Ultra-Sonic Pulse Velocity Test.



UPVT Mapping of Columns

EXCELLENCE	GOOD	DOUBTFUL	POOR
C3	C1	C5	C7
C11	C2	C6	C10
C31	C4	C9	C13
C32	C8	C17	C15
	C12	C20	C18
	C14	C21	C19
	C16	C23	C22
	C26	C24	C28
		C25	
		C27	
		C29	
		C30	

While testing fluctuation in readings occurred due to presence irregularities in concrete such as internal cavity, larger cracks, debonding of concrete cover, lack of uniformity in the concrete etc. From the test UPV Most columns are in poor condition which requires sudden maintenance or reconstruction.

Most columns are in poor condition which requires sudden maintenance or reconstruction. The reinforcing steel present in concrete highly effects the measurement of pulse velocity because pulse velocity in a steel is 1.2 – 1.9 times the pulse velocity of the plane concrete.

6.6 Cover Meter Test

cover meter results

CN	RANGE OF COVER CONCRETE (including cover)
C1	56-60
C2	46-49
C3	48-50
C4	48-50
C5	44-47
C6	42-46
C7	46-48
C8	48-50
C9	48-50
C10	45-48
C11	55-58
C12	58-60
C13	58-60
C14	54-57
C15	57-59
C16	58-60
C17	58-60
C18	45-47
C19	45-47
C20	45-47
C21	48-50
C22	57-59
C23	46-48
C24	46-48
C25	48-50
C26	45-48
C27	56-59
C28	56-58
C29	58-60
C30	50-60
C31	54-57
C32	57-59
C33	Highly spalled cover/cracks
C34	
C35	
C36	

Probable diameter of bars

COLUMN NO'S	REINFORCEMENT POSITION AND PROBABLE DIAMETER IN MM
C1, C11, C12, C13, C14, C15, C16, C17, C27, C28, C29, C30, C31, C32	Probable Dia-(30-19) (16-10) Ties were eroded completely in some portion of columns where it exposed Probable Dia of Ties (5-16)
C2, C3, C4, C5, C6, C7, C8, C9, C10, C18, C19, C20, C21, C22, C23, C24, C25, C26,	Probable Dia-(30-21) (25-12) Ties were eroded completely in some portion of columns where it exposed Probable Dia of Ties (5-16)

The cover meter test provided probable cover thickness, probable diameter of the bar of the existing reinforcement and exact location of reinforcement. From the obtained result reduction in cover thickness and rebar diameter is notice

VII. CONCLUSION

Based on the results obtained from the study the following conclusions made are as follows,

- It is noticed that, the roof of the existing structure was highly hazardous and the replacement is mandatory.
- The existing masonries are highly damaged and are significant for instant repair.
- The vertical members(column) lost their strength due to high range of cracks, spalling of concrete and internal cavity.
- The bottom portion of vertical members are impaired majorly as compared to other portions.
- The central columns are highly impaired and faced for quick retrofitting.
- The corrosion rate in existing RC members along with roof truss found to be extremely high.
- If the present condition's structure is left abeyance it will survive only for few years. Even if it is restored also it is temporary and is not such an economy.

VIII. ACKNOWLEDGMENT

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